Space Exploration Medical Evacuation Risk Assessments: A Qualitative Investigation

Human Research Program
Exploration Medical Capability Element
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"Expanding the Boundaries of Space Medicine and Technology"

Agenda

- Objective
- Background
- Approach
- Results
- Discussion
- Challenges & Limitations
- Lessons Learned

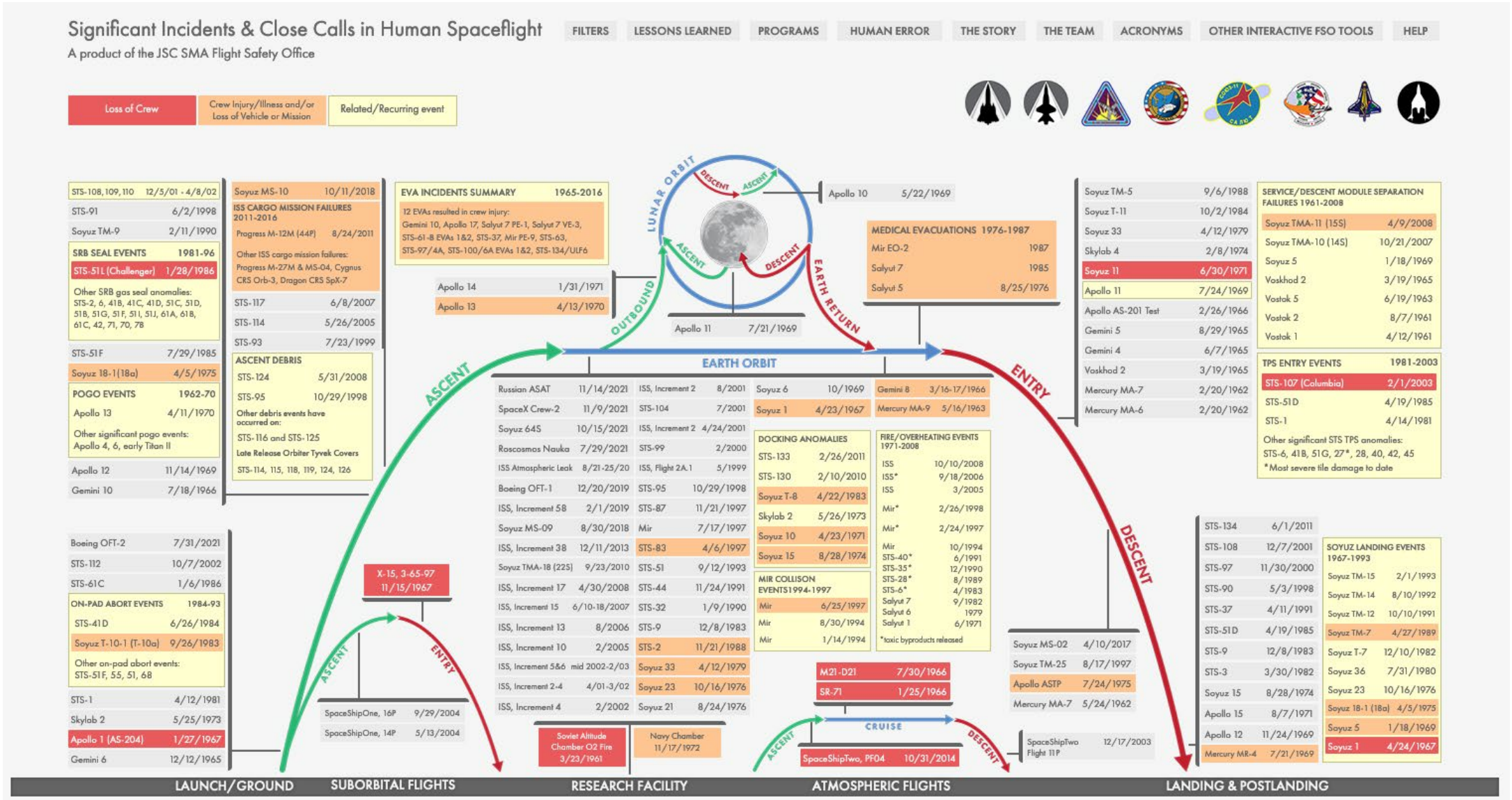
Objective

- Research Question: What unique risk assessment principles must be considered in space exploration medical evacuation (MEDEVAC) scenarios?
- Research Objectives:

  1: Identify common principles used to assess risks and benefits of MEDEVACs in extreme environments

  2: Identify common points of friction, complication, and challenges in extreme environment MEDEVACs

Background



[1]*Image courtesy of NASA*

Background

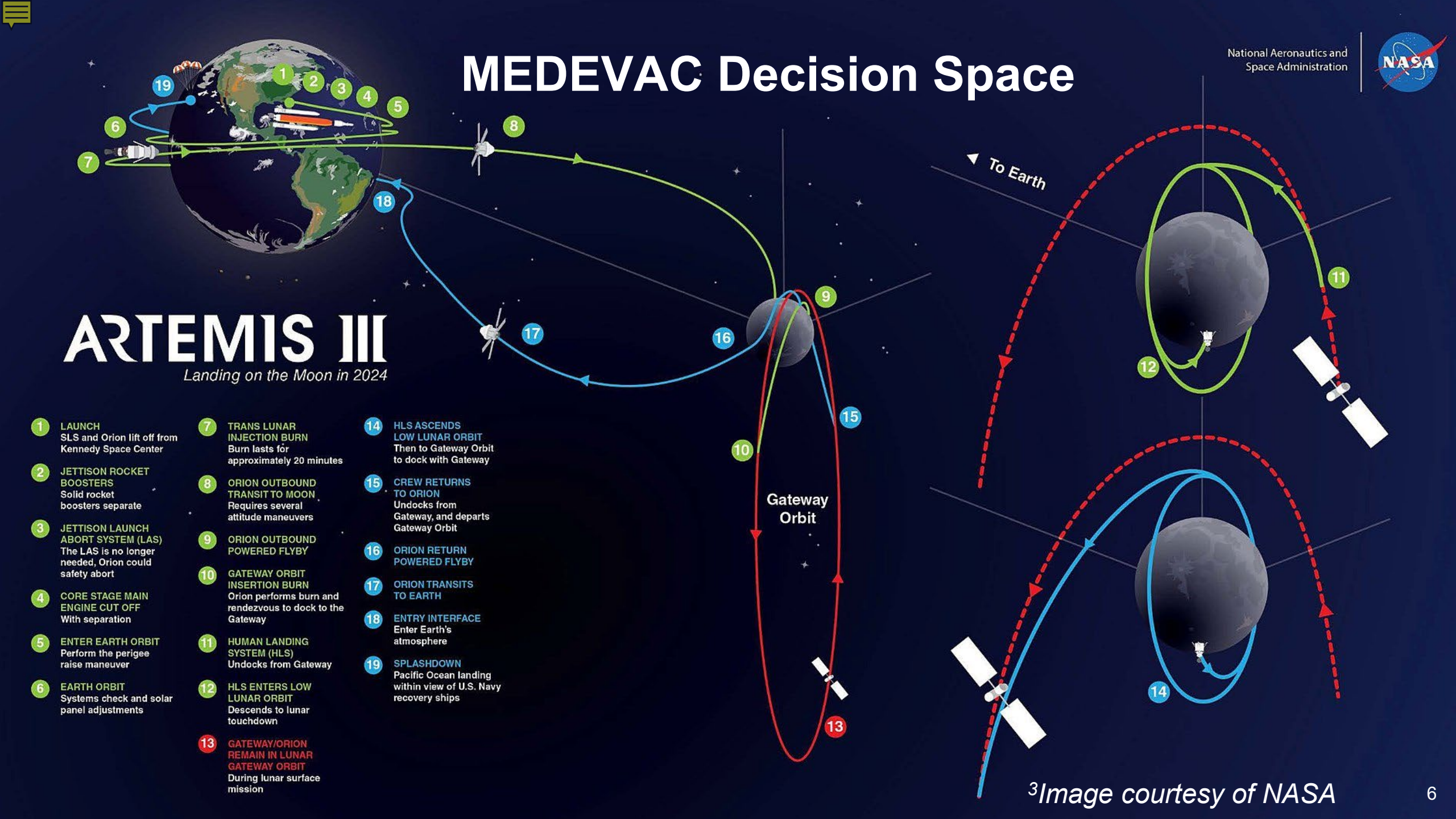
- LEO medical care includes:
  - Crew Medical Officer (CMO) with medical kits
  - Ground based consultation
  - MEDEVAC to Definitive Medical Care Facility (DMCF) within 24-48 hours
- Missions beyond LEO face:
  - Limited/No re-supply
  - Extended communication delays
  - Extended mission durations
  - Long MEDEVAC times

"How long should…a CMO…care for an acutely ill crewmember on orbit before calling for a MEDEVAC to a DMCF?" [2]

"It will be a weighty responsibility for a flight surgeon and flight director to determine…the need for a MEDEVAC." [2]

"…MEDEVAC scenarios turn even more complex in a mission beyond LEO." [2]

MEDEVAC Decision Space



[3]*Image courtesy of NASA*

Approach

- Methodology and Execution
  - In-depth semi-structured interviews
  - *Qualitative Thematic Analysis* using *Consensus, Co-occurrence and Comparison*
  - Analogs determined by mission, MEDEVAC complexity, and limited local medical capability
  - Audio anonymized, transcribed, and analyzed for emerging themes

Domain of Expertise (domain code)	
Wilderness (W)	2
Polar (P)	5
Combat (C)	4
Undersea (U)	2
Submarine (S)	3
Space (X)	4
Profession	
Physician (MD/DO)	13
Medical Provider (non-physician)	1
Military Officer	9
Flight Surgeon (NASA/Military)	5
Dive Medical Officer	1
Logistics Operations	1
Spaceflight Flight Director	1
Astronaut (NASA/ESA)	2

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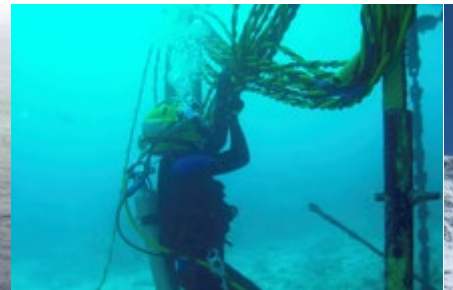



Results

- Data Collected:
  - 20 Semi-Structured SME Interviews 2020-2022
  - 22 hours of audio, 250,000+ words of transcription
- Results:
  - 18 themes
  - 2 Main Categories
    - Primary Risk Considerations
    - Contributing Factors
  - 1 Stand-Alone Theme: Decision Making

Categories	Themes
Primary Risk Considerations	Crew
	Environment
	Execution
	Experience
	Mission
	Patient(s)
	Provider
	Resources
	Time
Contributing Factors	Communication
	Crew Cohesion
	MEDEVAC Preparation
	Medical Support Planning
	Offsite Support
	Philosophy
	Political Considerations
	Psych Considerations
Other	Decision Making

Results

- Primary Risk Considerations
  - Nine themes described by SMEs and assessed by research team to be of primary importance when making a MEDEVAC decision
  - Mostly static values or concepts
  - The “MEDEVAC math” evaluated ***during the mission***

Results

Themes	Description	Representative Statements (Alpha-numeric code denotes domain and participant number per Table I)		
Crew	Mission members immediately impacted by MEDEVAC, not including those injured or sick	*Don't create more people needing to be evacuated* -W2	*The needs of the many outweigh the needs of the few.* -C3	*The rest of the crew covers down for as long as they can on the taskings at hand* -X4
Environment	The natural & constructed surroundings & how they impact the crew, patients, medical care, & modes of MEDEVAC	*Don't poke the bear. They're not deteriorating, just let them float there with no stress and get treated* -X4	*You may not be able to help anybody…you're just trying to survive…* -X4	*About 30 minutes after they left, they hit [a mine], and we saw all of them again…the risk is just ever present* -C1
Execution	The steps, settings, & processes required to transport a patient from the POI to a DMCF	*[You] try not to have the level of medical care or conditions deteriorate while…evacuating* -X1	*The stresses of entry and landing…then they're hours away from care…what can we treat [in space]?* -X1	*Can you get them in a suit, strapped down…maybe? I can't provide any care…maybe talk to them, that's it* -X3
Experience	Training and exposure of medical provider(s) & crew to medical skills, MEDEVACs, & risk trade-offs	*Here, I've got no shortage of help. I don't have to ask the janitor to scrub in, but…that may be the case* -C4	*We were less willing to tolerate medical risks with more advanced [MEDEVAC] capabilities.* -P2	*You need real experience of doing trade-offs of sick people…and balancing impact versus patient outcome* -W2
Mission	The explicit or implied purposes for the undertaking and the things required to achieve those purposes	*How do you evaluate the importance…a mix of how hard it was to get there and how likely we are to come back?* -W1	*We're going to shut down most of the station to make sure this person gets on a plane to safety.* -P5	*Once you launch to Mars, you've already made that decision…the mission is more important than the people* -X3
Patient(s)	The person(s) who have become sick or injured for whom a MEDEVAC is being considered	*Casualty status dictates everything.* -C4	*The [first patient] was getting better…now we have two patients, do we take two?* -P1	*If it could go either way, what does the patient want to do?* -P5
Provider	The person(s) providing medical care to the patient(s) regardless of training	*We make recommendations, but they're going to listen.* -X2	*You've got to preserve your provider at all times…* -P5	*They're the eyes and ears on the ground, but ultimately the decision isn't for the doctor on the ground.* -P5
Resources	Local & remote workforce, consumable, & durable goods for the mission or providing medical care	*The crew will have to decide: do you use all your consumables on one person?* -X4	*OK, so we do this Hail Mary surgery…what do we do now?* -P2	*We'll modify the standard treatment so we don't use as many resources or people* -C1
Time	Duration of medical stability, procedures, MEDEVAC, resources, and decision space	*Most of the time you don't have to make a split-second decision…now you've got to talk to people* -X1	*Could I wait 24-48 hours to spin up my nominal landing site?* -X1	*If you put a [patient] in the back of an open-bed truck for a four-hour drive, they're going to die.* -C1

Results

- Contributing Factors
  - Eight themes described by SMEs and assessed by research team to ***not*** be of primary importance when making a MEDEVAC decision
  - Can reduce risk and shape environment for a MEDEVAC
  - Adjusted ***pre-mission*** to influence the Primary Risk Considerations

Results

Themes	Description	Representative Statements (Alpha-numeric code denotes domain and participant number per Table I)		
Communication	Transmission, receipt, and understanding of information regarding medical issues, assessments, treatments, & MEDEVAC execution	*It really degrades communication. It takes longer. It increases frustration. It makes everything harder.* -X4	*And I had to explain why, because these are engineers and they [don't] understand …the medical issues* -X2	*With every handoff, there's some deterioration, and it's just like playing telephone.* -C1
Crew Cohesion	The level of camaraderie, bonding, & integration the crew has achieved before the mission begins	*I think crews on a deep space mission will be very, very close…they're not all good friends…like siblings.* -X5	*As a crew medical officer, that's your main goal is do the people trust you.* -X5	*We've established that trust and we were able to communicate with them.* -X2
MEDEVAC Preparation	Prior considerations, planning & rehearsals for MEDEVACs through both training and mission/vehicle design	*You won't get more training hours.* -X4	*[MEDEVAC] is not a pickup game.* -C3	*That's why we train for the things that we do…hoping that the scenario we meet on the real day is not nearly as tough…* -X1
Medical Support Preparation	Prior consideration, planning & rehearsals for medical scenarios through both training and mission/vehicle design	*I will tell you the medical team, the hours we get for medical training are few and far between.* -X4	*It's about $6k a year to support...We just made the call like we're not going to do it.* -W2	*Common things happen commonly…you have to think about high consequence, low incidence…as well* -W2
Offsite Support	The availability for remote resources, consultation, & guidance to be provided to the crew	*Whoever the lead surgeon is in Houston, it's that chief physician who makes the recommendation.* -X2	*…my team has been activated and they are available to provide full support…* -P3	*…if you're having a bad day… talk to your buddy…call your wife…if you're calling NASA…there's something weird* -X5
Philosophy	The underlying culture, approach, and acceptability for risk, casualties, and MEDEVAC planning	*…we're smart enough to figure it out* -X4	*Prepare them to be autonomous or just ask them to be careful and accept that they might die.* -X5	*…it all goes back to that priority scheme of crew safety, vehicle safety, mission.* -X1
Political Considerations	Broad organizational, national, and international impacts from the success or failure of a mission, crew injury, or loss of life	*…paratroopers die in a helicopter crash…and we almost shrug…we don't think like that for astronauts…* -X5	*…we don't want any narcotics because of the risk of diversion…that seems very shortsighted…* -W2	*…if an astronaut dies, it's bad for the astronaut…and national prestige…that drives the resources put into saving someone* -X5
Psychological Considerations	The mental health support, training, and assets provided in case of injury or the death of a crewmember	*…human spaceflight has to be the strongest link of the operation…resiliency, even for the most dedicated* -W2	*When you put people in those amounts of pressure…it's impossible to predict…the ones who are going to fold up.* -P5	*…being in the same camp where now there's people missing from seats, that's a different experience.* -C2

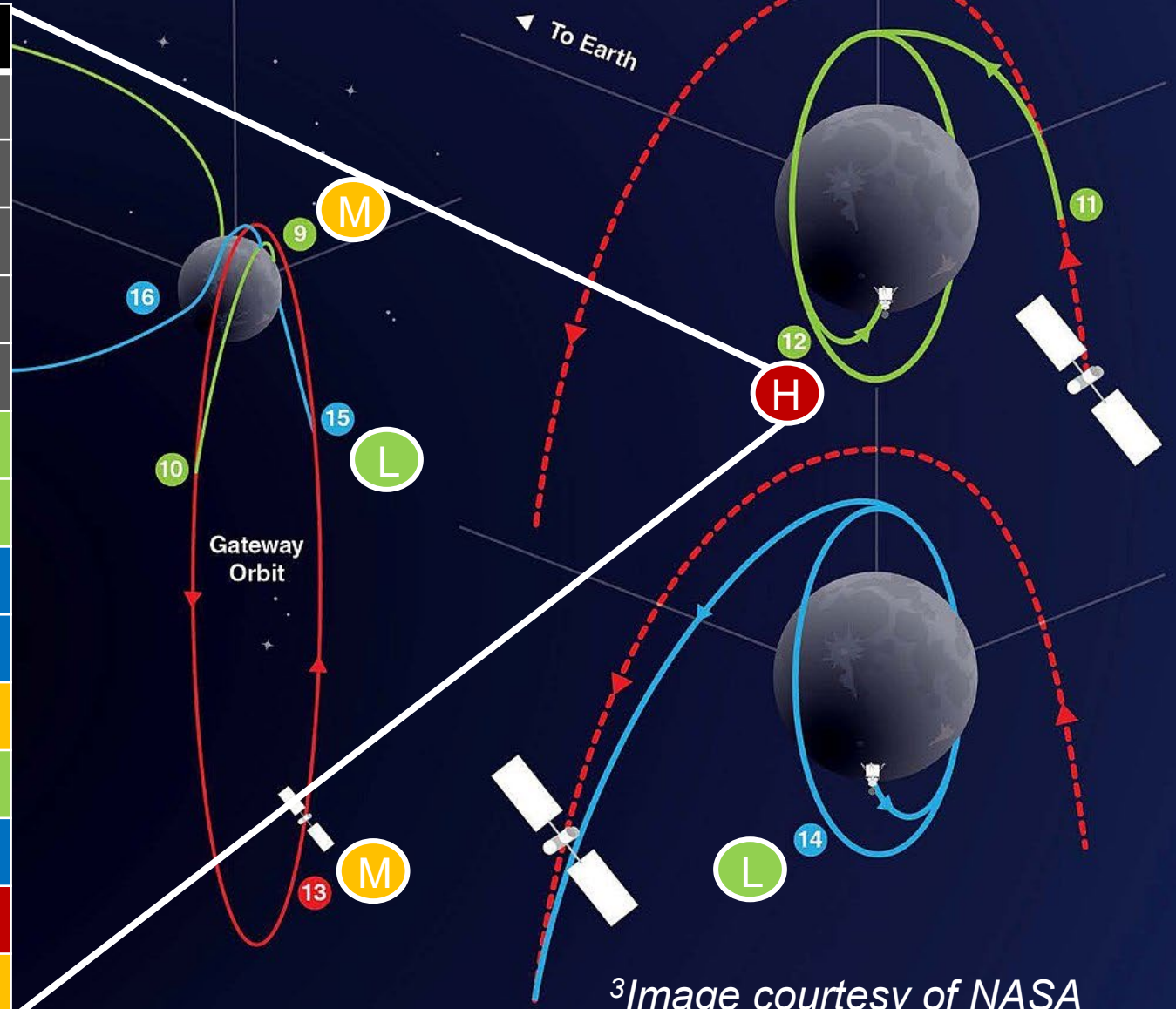
Results

- Decision Making
  - ***How*** MEDEVAC decisions are made, by ***whom***, at ***what level*** of an organization, and with ***what information***
  - Impacts both ***during the mission and pre-mission***

Theme	Description	Representative Statements		
Decision Making	How a MEDEVAC decision is made, by whom, at what level, & with what information	*Make your recommendations, but it's up to the commander* -C1	*You never tell the pilot it's a 3-year-old who's going to die if you don't go out* -P2	*You need roles, responsibilities, & decisions made at the right places…the lowest possible level* - X2

Mission CONOP MEDEVAC Risk Analysis

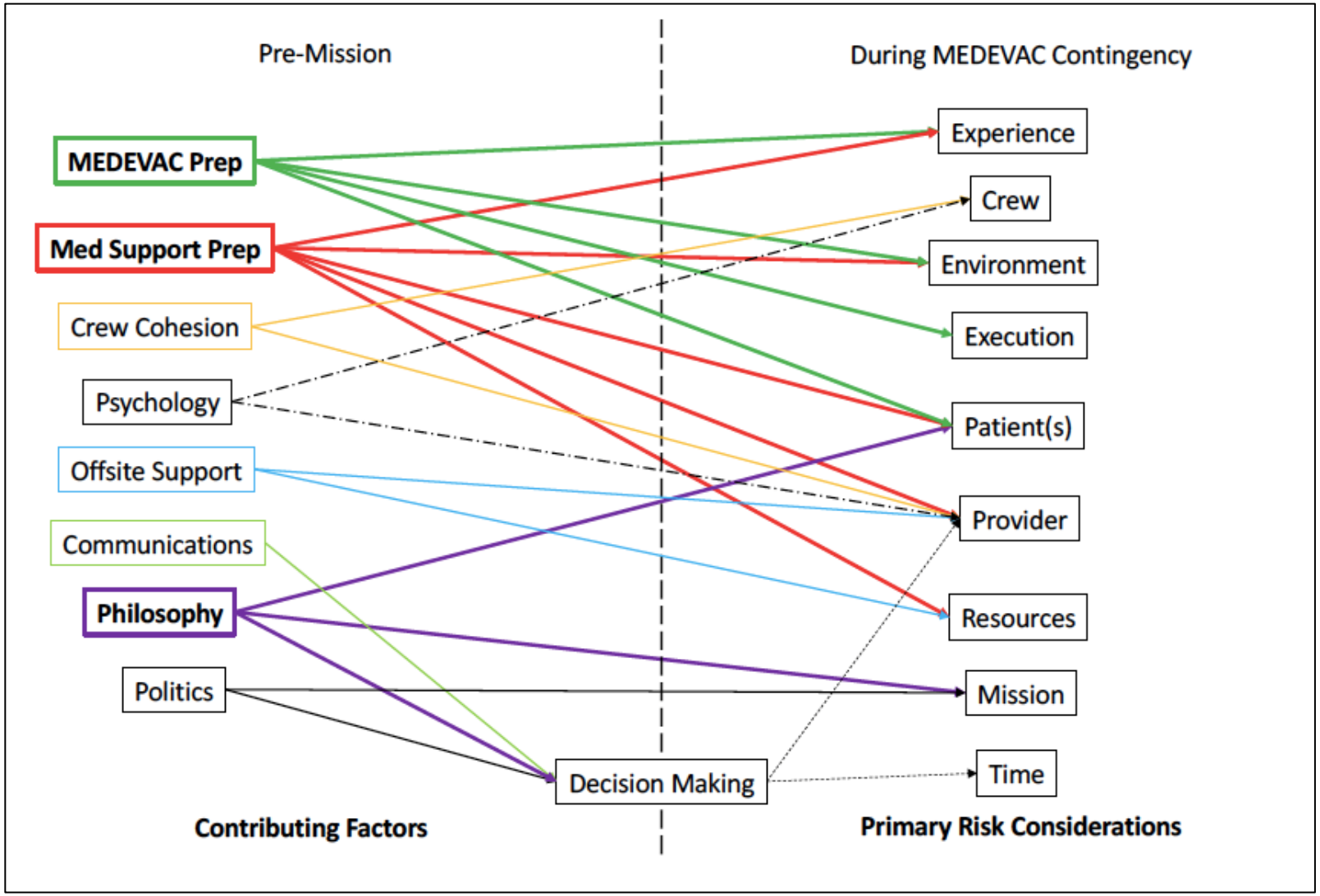
MEDEVAC Risk Analysis	
Artemis III Mission Phase 12/13: Lunar EVA Ops	
MEDEVAC Concept: Lunar Surface -> Gateway	
Medical Incident Level: II	
Overall Score: High (Resources)	
Category	Score
Crew	+
Environment	+
Execution	0
Experience	0
Mission	++
Patient(s)	+
Provider	0
Resources	+++
Time	++



[3]*Image courtesy of NASA*

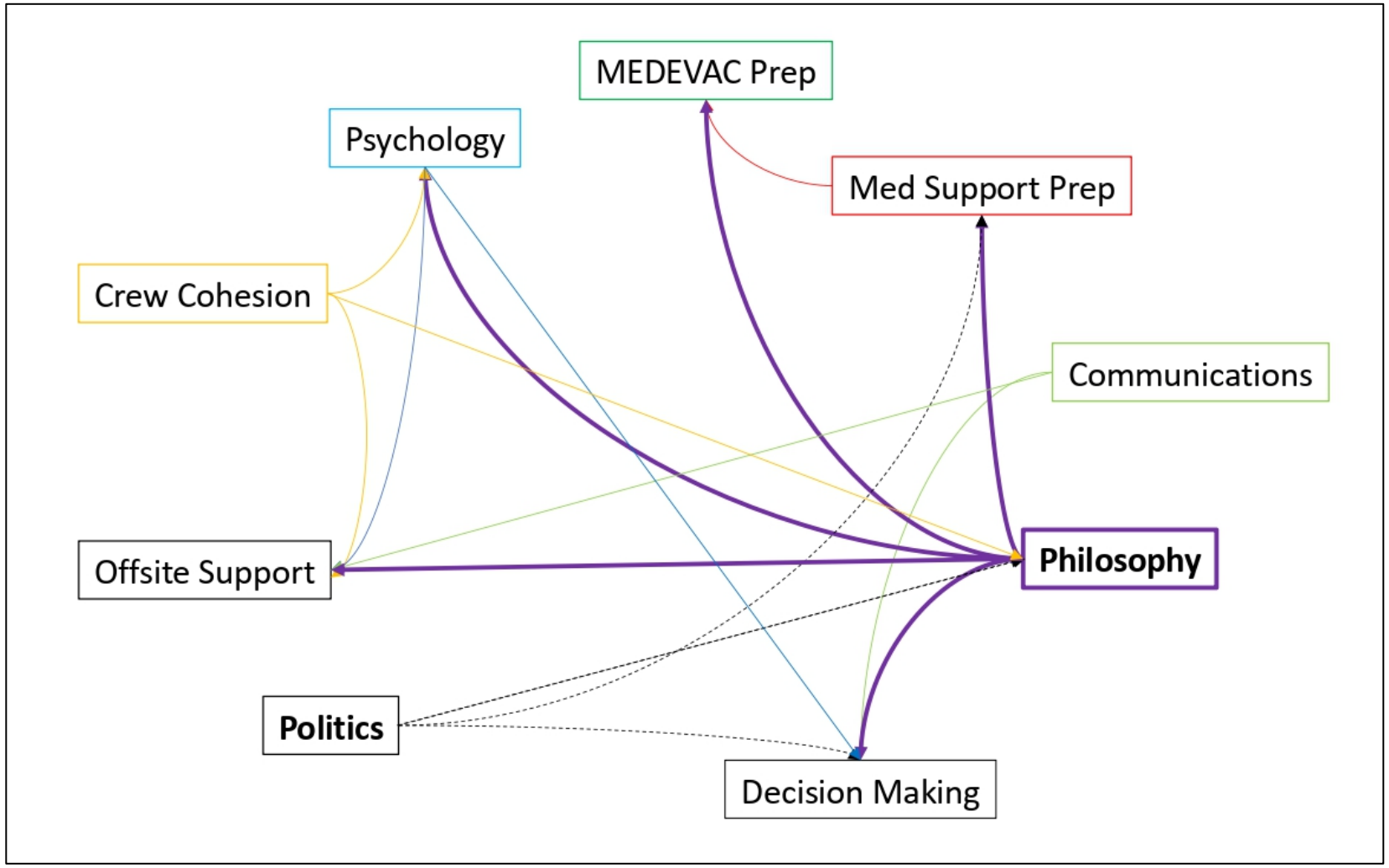
Discussion

Inter-Category Connections



Discussion

Contributing Factors Intra-Category Connections



Challenges & Limitations

- Challenges
  - Operational constraints on several SME Interviews
  - Several conflicting or opposing opinions

- Limitations
  - Qualitative nature of data and analysis
  - Research team familiar with MEDEVACs and spaceflight

Lessons Learned and Forward Work

- Lessons Learned
  - MEDEVAC decision space is broad and complicated
  - Exploration vs LEO missions bring new aspects into consideration (e.g. mission, politics, psych, philosophy)
- Forward Work
  - Work submitted for publication
  - NASA Earth Independent Medical Operations Working Group
  - Define objective criteria within risk categories/themes
  - Pair with IMPACT tool to ID phases with high-probability for medical event/MEDEVAC for risk assessments

References

1. Packham, N., & Ali, F. (2020). Significant incidents & close calls in human spaceflight. NASA JSC S&MA Flight Safety Office, JS-2015-004 NNJ13RA01B.
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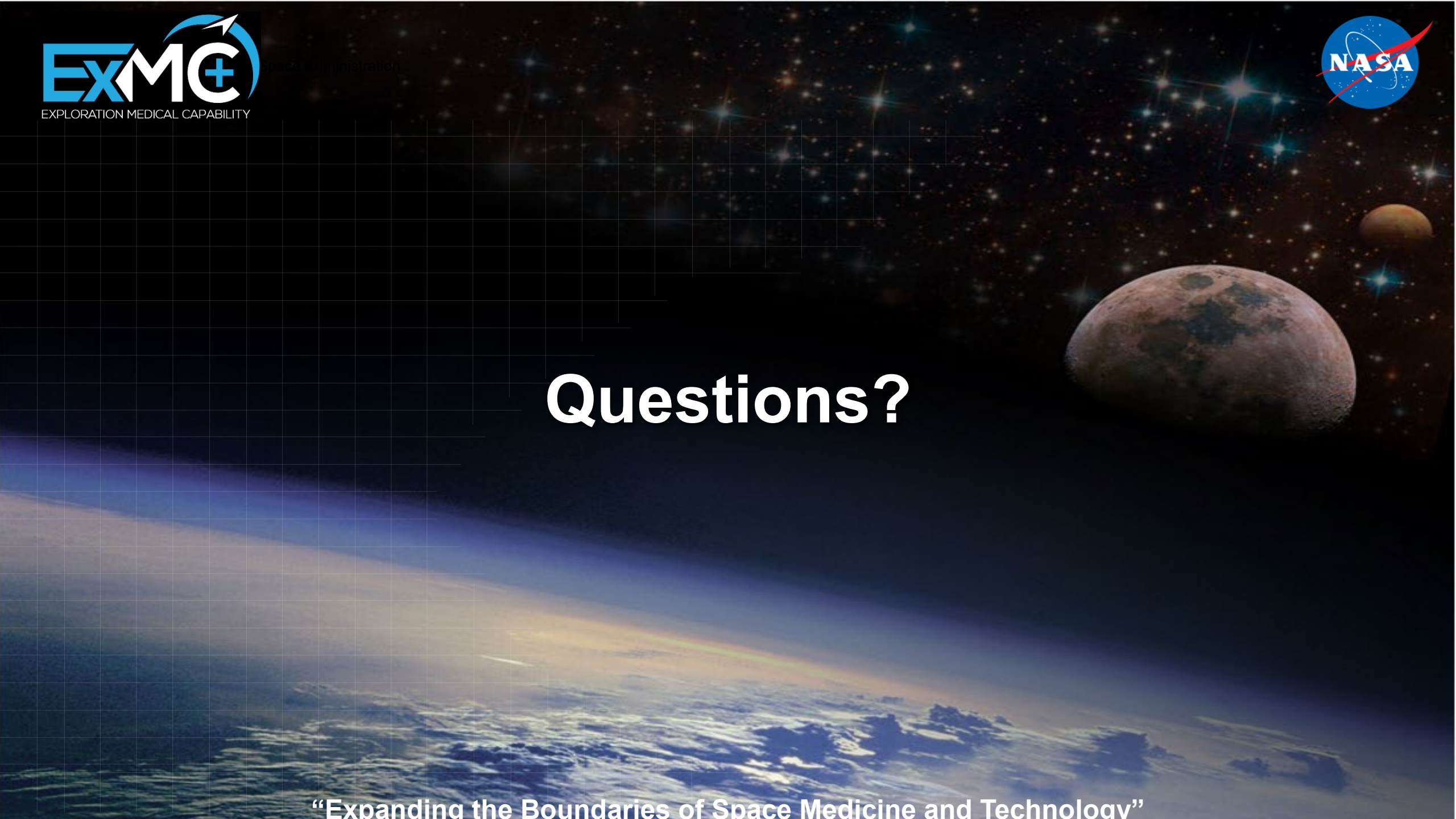
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